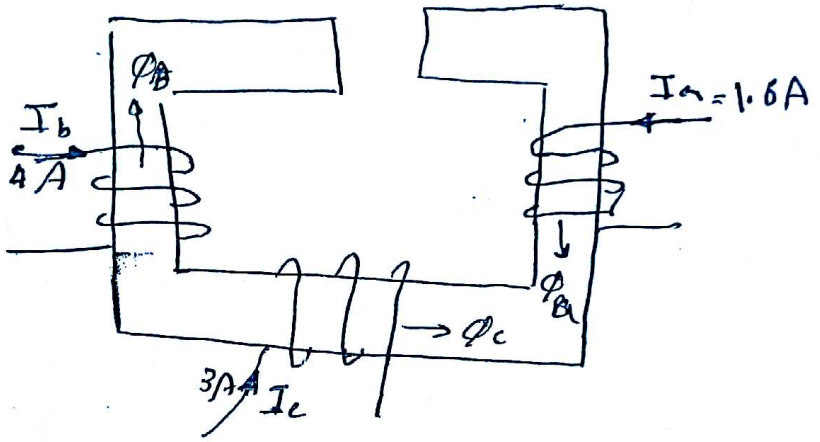
2018-1-4 EE352 تأجيل

س.م

P1 An iron core as shown in Fig (1). It has a mean length of magnetic path of 100cm, cross section area of (2cm x 2cm Permeability of 1400, and an air gap of 5mm cut in the core The three coils carried by the core have number of turns $N_A = 335$ $N_B = 800$ and $N_C = 600$; and the respective currents are 1.6A, 4A and 3A. Find the flux in the air gap.



$l = 100\,cm$, $A = 2 \times 2 = 4 \times 10^{-4}\,m^2$ $\mu_r = 1400$ turns.

$l_g = 5 \times 10^{-3}\,m$

By using Ampere's law.

$$\phi_c R_c + \phi_g R_g = N_A I_A + N_B I_B - N_C I_C \longrightarrow (1)$$

$$4 \times 600 + 1.6 \times 335 - 3 \times 600 = \phi (R_c + R_g)$$

$$1163 = \phi (R_g + R_c) \qquad \because R_c = \frac{l_c}{\mu_o \mu_r A} \;,\; R_g = \frac{l_g}{\mu_o \mu_r A}$$

$$\therefore 1163 = \frac{\phi}{\mu_o A} \left[\frac{l_c}{\mu_r} + \frac{l_g}{1} \right]$$

$$1163 \times 4\pi \times 10^{-7} \times 4 \times 10^{-4} = \phi \left[\frac{100 \times 10^{-2}}{1400} + 5 \times 10^{-3} \right].$$

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$$\phi = \frac{1136 \times 4\pi \times 10^{-7} \times 400 \times 1}{5.7 \times 10^{-5}} = 0.099 \text{ mWb} \approx 0.1 \text{ mWb}$$

P2 For the system shown in Figure (2) (assume the air gap remains fixed and the relative permeability of the iron core is infinite).

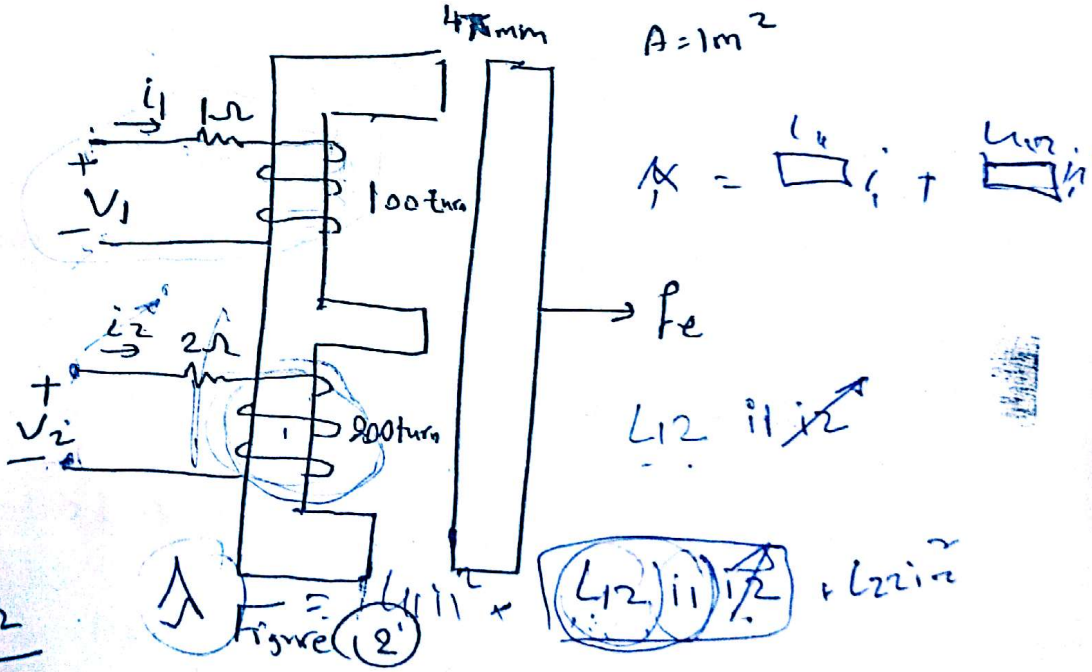
a- Determine L_{11}, L_{12}

b] If $i_1(0) = 0A$. The secondary is open circuited and $V_1 = 10V$ is applied at $t = 0s$, determine V_2, W_e, W_m and f_e at $t = 1s$.

$V_2 = L_{12} \frac{di}{dt}$

t

i_1



$\lambda = L_1 i_1 + L_{12} i_2$

$L_{12}\, i_1 i_2$

$\frac{1}{2} L_{11} i_1^2 + L_{12} i_1 i_2 + \frac{1}{2} L_{22} i_2^2$

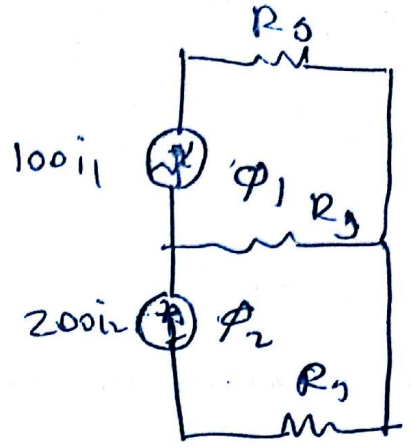
$L = N_1 N_2$

Solution

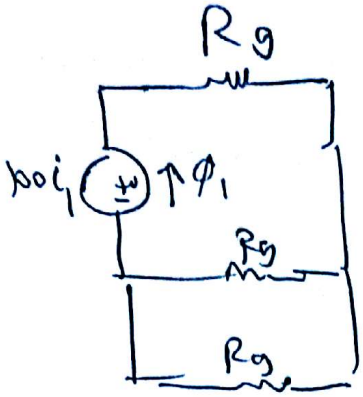
a] $\because \lambda_1 = L_{11} i_1 + L_{12} i_2$, $\lambda_2 = L_{21} i_1 + L_{22} i_2$.

By using two port Network technique (Note we can use superpos

$$L_{11} = \frac{\lambda_1}{i_1}\bigg|_{i_2=0}$$



For $i_2 = 0$



$$R_T = (R_g \| R_g) + R_g$$

$$R_T = \frac{R_g}{2} + R_g = \frac{3}{2}R_2$$

$$R_T \phi_1 = N_1 i_1 \Rightarrow \phi_1 = \frac{100\, i_1}{R_T} \Rightarrow$$

$$\therefore \phi_1 = \frac{100\, i_1}{3/2\, R_g} = \frac{200\, i_1}{3 R_g}$$

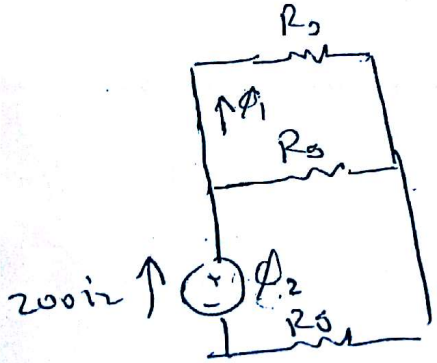
$$R_g = \frac{l_g}{\mu_0 A_g} = \frac{4\pi \times 10^{-3}}{4\pi \times 10^{-7}} = 10^4$$

$$\lambda_1 = N_1 \phi_1 \Rightarrow \lambda_1 = \frac{(200 \times 100)\, i_1}{3/2 \times 10^4}$$

$$\therefore \lambda_1 = \frac{2 \times 10^4}{3 \times 10^4} i_1 = \frac{2}{3} i_1$$

$$\because \lambda_1 = L_{11} i_1 \Rightarrow \boxed{L_{11} = \frac{2}{3}}$$

$$L_{12} = \frac{\lambda_1}{i_2}\bigg|_{i_1=0}$$



$$\phi_2 = \frac{200 i_2}{3/2\, R_g}$$

$$\because R_g = 10^4$$

$$\therefore \phi_1 = \frac{\phi_2}{2} = \frac{200 \times i_2}{3/2 \times 10^4} \cdot \frac{1}{2} = \frac{200 i_2}{3 \times 10^4}$$

$$\therefore \lambda_1 = N_1 \phi_1 = \frac{100 \times 200\, i_2}{3 \times 10^4}, \quad \frac{2 \times 10^4}{3 \times 10^4} i_2$$

$$\therefore \boxed{L_{12} = L_{21} = \frac{2}{3}}$$

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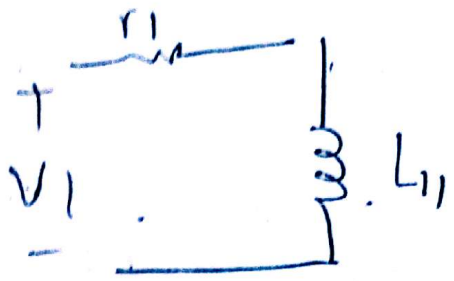
(b)



$V_2 = L_{12}\frac{di}{dt}$

secondary open $\Rightarrow i_2 = 0$

$V_1 = i_1 r_1 + \frac{d\lambda_1}{dt}$

$V_2 = i_2 r_2 + \frac{d\lambda_2}{dt}$

$\lambda_1 = L_{11} i_1 + L_{12} i_2$ ($i_2 = 0$)

$\lambda_2 = L_{21} i_1 + L_{22} i_2$ ($i_2 = 0$)

$\therefore V_1 = r_1 i_1 + L_{11}\frac{di_1}{dt}$, $V_2 = L_{12}\frac{di_1}{dt}$

By using Math 4 or Solving first order equations. yields

$i_1 = 10(1 - e^{-\frac{3}{2}t}) \Rightarrow i_1 = 10(1 - e^{-3/2t})$.

$W_m = \int f_e \cdot \frac{dx}{dt} \cdot dt = 0$ ($\frac{dx}{dt} = 0$)

$W_e = W_f = \frac{1}{2} L_{11} i_1^2$

$V_2 = \frac{2}{3}\left[\frac{3}{2} e^{-\frac{3}{2}t}\right] = e^{-3/2t}$

$F_e = \frac{\partial W_c}{\partial x} \Rightarrow i_2 = 0$

$W_c = \frac{1}{2} L_{11}(x)\, i_1^2 \Rightarrow L_{11} = \frac{N^2}{R(x)}$

$L_{11} = \frac{2\times10^9 \cdot 4\times10^{-7}}{x} = \frac{8\times10^{-7}}{x}$

$\frac{\partial L_{11}}{\partial x} = -\frac{8\times10^{-7}}{x^2}$

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$$F_e = -\frac{8\pi\times10^{-3}}{x2}\cdot\frac{1}{2}i_1^2 = -\frac{4\pi\times10^{-3}}{x^2}i_1^2$$

$$F_e = -\frac{4\pi\times10^{-3}}{(4\pi\times10^{-3})^2}\,100\left(1-e^{-3/2t}\right)^2$$

$$\boxed{F_e = -\frac{100\left(1-e^{-3/2}\right)^2}{4\pi\times10^{-3}} = -4.8\times10^3\,N}$$

Q3 A Ring sample of iron, fitted with a primary and secondary winding is to be tested by the method of reversals to obtain its (B/H) curve. In such a test, the primary winding of (400 t) carries a current of (1.8 A) on reversal a change of flux linkage ($\lambda = N\Phi$) of (8×10^{-3} Wb-turn) is recorded in the secondary (40 turns). The square is made up of (50 laminations), each (0.5 mm) thick with outer and inner diameters of 25 cm and 23 cm respectively. Assuming uniform flux distribution determine values of B, H & μ.

Here change of flux linkage $\lambda = 2\Phi N_2 = 8\times10^{-3}$.

$\lambda = 2\Phi N_2$

$\therefore \Phi = \frac{8\times10^{-3}}{20} = 4\times10^{-4}$ Wb.

$\therefore A = 2.5\times10^{-4}\,m^2$

$B = \frac{\Phi}{A} = \frac{4\times10^{-4}}{2.5\times10^{-4}} = 1.6\,Wb/m^2$

$\lambda = 2\Phi N$

$8\times10^{-3} = 2\Phi N_{10}$

Φ

23 25

$\therefore Hl = NI \Rightarrow H = \frac{NI}{l} = \frac{400\times1.8}{0.24\pi} = 955\,AT/m$

$\mu_0\mu_r = \frac{B}{H} \Rightarrow \mu_r = \frac{B}{\mu_0 H} = \frac{1.6}{4\pi\times10^{-7}\times955} = 1333.$

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2018-1-8 يوجد EE352 Tutorial

Q1 The maximum flux density in the core of a 250/3000 Volt 50 Hz single phase transformer is 1.2 Wb/m². If the mmf per turn is 8 Volt determine:-

(1) primary and secondary turns (2) area of the core.

(i)

$E_1 = N_1 \times emf \Rightarrow N_1 = \frac{250}{8} = 32$, $N_2 = \frac{3000}{8} = 375$.

(ii) $E_2 = 4.44 f_m N_2 B_{max} A \Rightarrow$

$3000 = 4.44 \times 50 \times 375 \times 1.2 A \Rightarrow A = 0.03 m^2$.

Q2 The core of a 100 KVA, 11000/550 V, 50 Hz 1ph core type transformer has a cross section of 20cm x 20cm. Find (i) the number of H.V and L.V turns per phase and (ii) the emf per turn if the maximum core density is not to exceed 1.3 Tesla. Assume a stacking factor of 0.9 what will happen if its primary Voltage is increased by 10% on no load.

(i) $B_m = 1.3$ T, $\Rightarrow A = (0.2 \times 0.2) \times 0.9 = 0.036 m^2$.

$E_1 = 4.44 f N_1 \Phi_{max}$ ($\Phi_{max} = BA$) $\Rightarrow 11000 = 4.44 \times 50 \times N_1 \times 1.3 \times 0.036$

$\therefore \boxed{N_1 = 1060 \text{ turn}}$

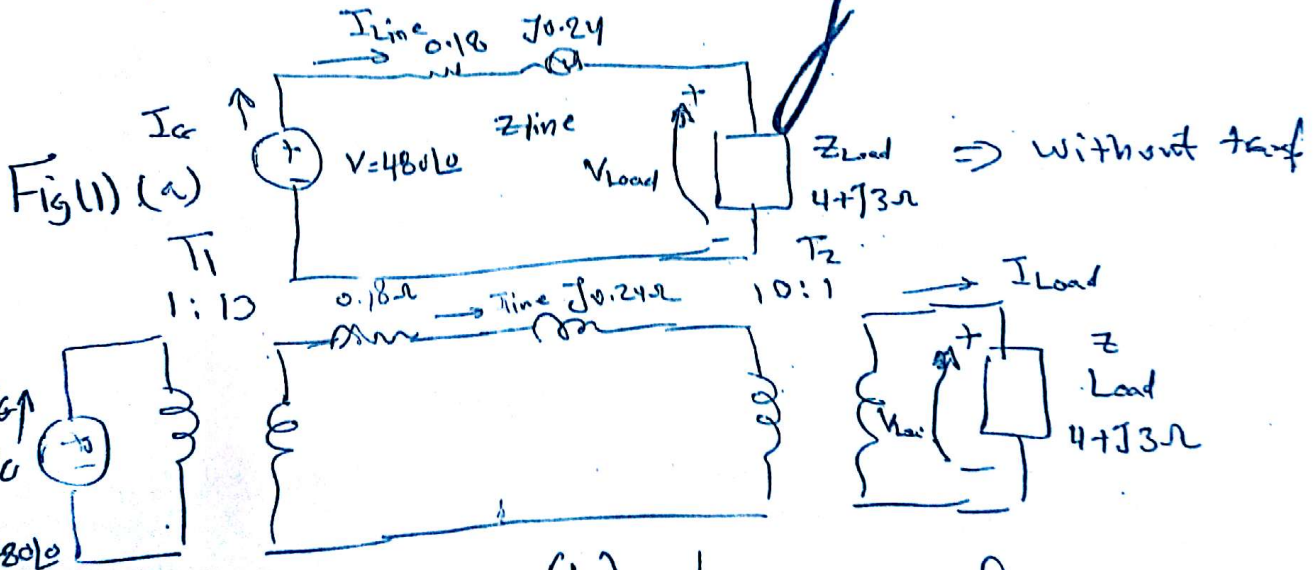
$\boxed{N_2 = K N_1 = \left(\frac{550}{11000}\right) \times 1060 = 53}$

(ii) emf/turn $= \frac{11000}{1060} = 10.4$ Volt or $550/53 = 10.4$ V.

Keeping supply frequency constant, if primary voltage is increased by 10%, magnetising current will increase by much more than 10%. However due to saturation, flux density will increase only marginally and so will the eddy current and Hysterisis losses.

Q3 A single phase power system consists of 480V, 60 Hz generator supplying a load $Z_{Load} = 4+j3\,\Omega$ through a transmission line of impedance $Z_{line} = 0.18+j0.24\,\Omega$. Answer the following question. about this system

(a) If the power system is exactly as described in Fig (1). what will the voltage at the load be? what will the transmission line losses be?



Fig(1) (a) ⇒ without transformers

Fig(1) (b) ↳ with transformers.

Fig(1) a (a) From the power system without transformers Hence

$$I_G = I_{line} = I_{Load} = \frac{V}{Z_{line} + Z_{load}} = \frac{480\angle 0}{(0.18+j0.24)+(4+j3)} = 90.8\ A$$

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The load voltage is

$$V_{Load} = I_{line} Z_{Load}$$

$$V_{Load} = (90.8 \angle -37.8° A)\ (4+j3) = 454 \angle -0.9 \text{ volt.}$$

line losses are

$$P_{losse} = I_{lin}^2 R_{line} = (90.8)^2 (0.18) = 1484 \text{ Watt.}$$

(b) Suppose a 1:10 step up transforme is placed at the generator end of transmission line and 10:1 step down transformer is placed at the Load end of the line (Fig (1) b) what will the Load voltage be now? What will the transmission line losses be now.?

The value of the Load's impedance when reflected to the transmiss system is voltage is.

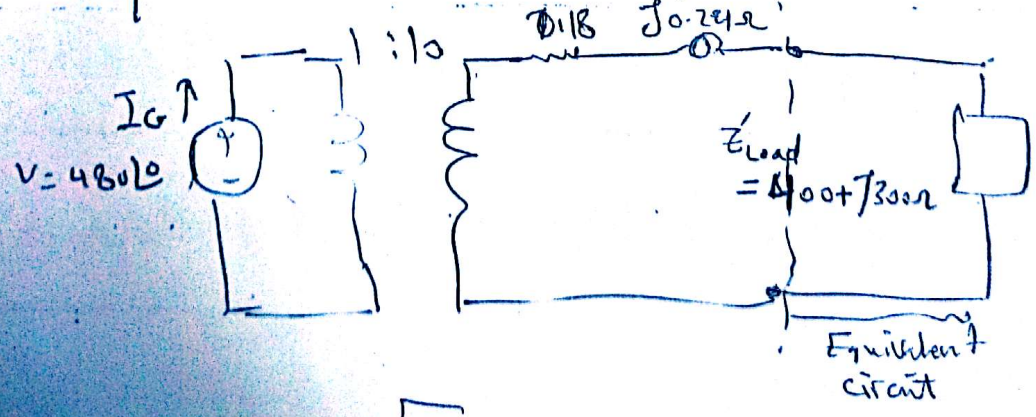
$$Z_{Load} = a^2 Z_{Load}$$

$$= \left(\frac{10}{1}\right)^2 (4+j3) = 400+j300\ \Omega.$$

The total impedance at the transmission line level is now

$$Z_{eq} = Z_{line} + Z_{load}$$

$$Z_{eq} = 400.18 + j300.24\ \Omega = 500.3 \angle 32.98°\ \Omega$$



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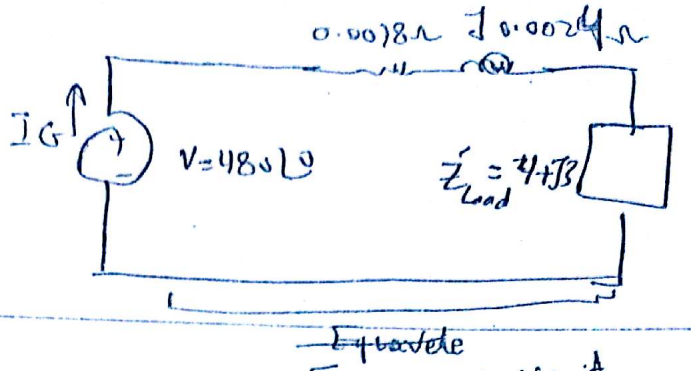

Equivalent circuit

$$Z'_{eq} = a^2 Z_{eq} = a^2 (Z_{line} + Z'_{Load})$$

$$= \left(\frac{1}{10}\right)^2 (0.18\Omega + j0.24\Omega + 4\Omega + j3\Omega)$$

$$Z'_{eq} = (0.0018\Omega + j0.0024\Omega + 4 + j3) = 5.003\angle 36.88\ \Omega.$$

$Z'_{Load} = 4 + j3$, $Z'_{Line} = 0.0018 + j0.0024\ \Omega$.

The current $I_G = \dfrac{480\angle 0\ V}{5.003\angle 36.88^\circ\ \Omega} = 95.94\angle -36.88^\circ\ A.$

For T_1 ⇒ turns ration is $N_{P1} : N_{S1}$, T_2 turns ration is $N_{P2} : N_{S2}$

$$\frac{I_{line}}{I_G} = \frac{N_{P1}}{N_{S1}} \Rightarrow I_{line} = \frac{1}{10}(95.94\angle -36.88) = 9.594\angle -36.88$$

$$I_{Load} = \frac{N_{P2}}{N_{S2}} I_{Line} = \frac{10}{1}(9.594\angle -36.88^\circ) = 95.94\angle -36.88^\circ\ A$$

$$\therefore V_{Load} = I_{Load}\ Z_{Load} = (95.94\angle -36.88)(5\angle 36.87) = 475.7\angle -0.01\ Volt$$

$$P_{losses} = I_{Line}^2 R_{line} = (9.594)^2 (0.18) = 16.7\ watt.$$

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(11) A 10KVA, 1phase, 50Hz, 500/250 Volt transformer gave following test results:.

OC test (LV) side: 250V, 3A, 200watt

SC test (HV) side 15V, 30A, 300W.

Calculate efficiency and regulation at full load 0.8 pf lagging.

∵ F.L current = $\frac{10,000}{250}$ = 40A.

Short circuit test data have been given at 30A on the l.v side.

i^2r losses at 40A. L.V side = $\left(\frac{40}{30}\right)^2 \times 300$ Watt = 533.3 watt.

At rated Voltage iron losses = 200watt.

FL output at 0.8 pf = 10000 × 0.8 = 8000watts.

$\eta\% = \frac{8000}{8000 + 733.3} \times 100 = 91.6\%$

For regulation From S.C test we found Z, Req

$Z = \frac{15}{30} = 0.5\Omega$, $Req = \frac{300}{30 \times 30}$, 0.333Ω

$X_{eq} = \sqrt{Z^2 - Req^2} = \sqrt{(0.5)^2 - (0.333)^2} = 0.373\Omega$.

Regulation

$\therefore V_R = \frac{4.0}{250}\left[0.333 \times 0.8 - 0.373 \times 0.6\right] = 6.82 \times 10^{-3}$ p.u

$\therefore$ Regulation $= 6.82 \times 10^{-3} \times 250 = 1.7$ Volt

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